Notes respecting a Re-eroded Channel-way. By John J. Stevenson, Professor of Geology in the University of the City of New York. (With three wood cuts.)

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The north branch of the Canadian river is formed near west longitude 104° 30′ at about 25 miles south from the northern boundary of New Mexico by two small streams, which rise in the Raton hills and drain much of the Trinidad Coal Field. Within 25 miles, the river enters a cañon, which deepens rapidly until, at 50 miles from its head, its nearly vertical walls are almost 1100 feet high, while the width of the gorge at the bottom varies from 150 to 800 feet. Thus far no important tributary enters the river in the cañon, but the petty side-cañons show that at some time or other much water must have flowed in from the Canadian plains. At probably 50 miles from the head of the cañon the Canadian river is increased by the Mora river, which rises on the east slope of the Las Vegas range and flows eastward to the Canadian. Its cañon becomes close at a little way south from Fort Union, and thence to the Canadian the river flows at the bottom of a gorge with bold vertical walls, becoming higher as the stream descends, until at the mouth of the cañon they rise to 1090 feet above the "bottom," where some half savage Mexicans gain a scanty livelihood by cultivating little patches of corn and melons.

Both cañons have the hard Upper Dakota sandstone as their rim, and that rock is the surface rock of the plains between the cañons, where a few relics of the Middle Cretaceous beds remain, protected by a plate of basalt which covers the Low Mesas or Table hills.

An extinct volcano, at 7 miles east from Fort Union, forms the southern extremity of the Turkey mountains—the Gallinas hills of Dr. Newberry's San Juan report—a curious qua-qua-versal, which deserves much closer study than could be given to it by either Dr. Newberry or myself. The volcano has been visited by Dr. Newberry, Dr. LeConte, Dr. Hayden and the writer. The crater still retains its form and the rim is broken only on the southern side, an imperfection due, perhaps, in some measure to erosion, but in greater part to the pressure of the lava. The eruption to which this mountain owes its origin occurred in the later Tertiary, and the lava is basaltic.

The basalt extends northward but a very little distance and the flow was toward the south through the breach in the crater. The lava was followed from the breach directly to the Mora cañon, the passage beginning along an arroyo or dry water course, where the basalt rests on Upper Dakota sandstone, though occasionally a little débris intervenes. At one locality, some tufaceous limestone, characteristic of the Santa Fé Marls, belonging to the Loup River epoch, is included in the débris.

Entering the Mora cañon, the basalt followed the gorge to its mouth, and was in such volume as to flow up the Canadian cañon to a distance of near-

ly three miles. How far it went below the mouth of the Mora cañon was not ascertained. The continuity of the flow is distinct throughout and the general features of the rock in the Canadian cañon are the same with those observed in the crater itself.

A solid crust forms quickly on the surface of cooling basalt. It is probable, therefore, that the Mora river was not long displaced; but that it, as well as the Canadian, soon regained its channel and began once more the work of corrasion. The features shown in the cañons are of no small interest, for the extent of erosion prior to the basalt flow is as clearly exhibited as is the extent of the erosion since that event. The features are best studied in the Mora cañon, at the mouth of which the following measurements were obtained:

1. From river surface to bottom of basalt..... 230′
2. " same to top of basalt..... 620′
3. " " brink of the chasm..... 890′
4. " " top of wall.....1090′

The chasm is therefore 230 feet deeper than when the basalt flood took possession of it.

As the present cañons do not wholly coincide with the ancient gorges, the numerous curves exhibit the base of the basalt sheet very satisfactorily. The old valley of the Mora was benched or slightly terraced, so that the lava rests against a wall of sandstone, and overflows the bench of which that is the escarpment, as is shown in fig. 1:

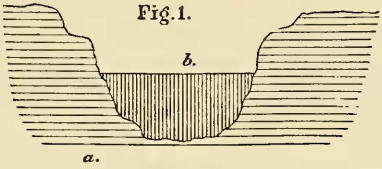

Fig. 1.

Fig. 1.—Showing form of the ancient cañon. *a.*—Dakota sandstone. *b.*—Basalt.

A breccia frequently appears in the bottom of the sheet, as though the molten rock had caught up débris in its flow.

The basalt terrace at the junction of the cañons indicates that the ancient cañon of the Canadian was much wider than that in which the river now flows.

The south-west wall of the old cañon lies at nearly a mile further from the river than does the present wall, which is capped by the sheet of basalt. It is very evident that before the basalt outpouring occurred the cañons had been digged down at their junction to 860 feet below the present level of the plain, and that the depth was reduced to 470 feet by the influx. But since the streams regained their channel-ways, material to the depth of 620 feet has been removed by corrasion; so that the vertical cutting since the flow ceased is very nearly equal to that done before the flow began. This cutting is wholly the result of corrasion, the wear of the streams upon their beds.

The enormous erosion on the plains and in the tributary cañons must have antedated the Turkey Mountain eruption. The basalt rests on the Dakota sandstone between the crater and the Mora cañon ; it has flowed into the tributary cañons, where it still remains ; the stream is almost wholly continuous across the plain ; the surface of the sheet is scarcely scarred in the side cañons ; while on the terraces of the Mora cañon and on the broad terrace between that and the Canadian cañon, the surface is as regular as though the flow had occurred less than 100 years ago. Such facts make it sufficiently clear that since the Turkey Mountain eruption, the rainfall has been comparatively insignificant. But this season of dryness must have been preceded by one of much greater rainfall, unless, indeed, we conceive that the erosion had been continuing for an indefinite period. But a moment's consideration will show that such a continuance is impossible ; remnants of the Colorado shales remain on the plains as mesas nearly 1000 feet high, which have been protected from erosion by a thick plate of basalt. This plate, which covers the Canadian hills east from the Turkey mountains and is an outlier of a vast basaltic area, marks the occurrence of a previous outpouring, not earlier than the beginning of the Pliocene. The enormous erosion, then, must have been performed during the interval between the eruptions, which, in a geological sense, could not have been very long. There seems, therefore, no room for doubting that a great climatal change passed over this region ; that during the interval between the eruptions the rainfall was great, sufficing for the removal of the thick Colorado group and the digging out of the many imposing arroyos or side-cañons, but that since the later Pliocene the region has been arid, the corrasion of the cañons having been done by water drained from the mountains.

But the new cañons do not coincide with the old ones. A small bit of basalt caps a hill in the Canadian cañon, at somewhat more than 2 miles above the mouth of Mora river ; within a short distance lower, the cañon bends westward, and the thick bed of basalt is well exposed, covering a terrace on the south wall ; soon the gorge curves southward and becomes very narrow as it passes through the basalt, which caps both walls, its base being nearly 200 feet above the stream. But within one-fourth of a mile, a slight bend eastward carries the cañon beyond the basalt, which now lies only on the western wall and covers a bench, stretching thence to the cañon of Mora river. A fragment of basalt remains in the former cañon on an isolated hill almost immediately below the mouth of Mora.

The present cañon of Mora river has the basalt altogether on its northeasterly side for a distance of nearly a mile and a half, and a fragment of the old westerly wall still remains as an irregular conical hill, rising above the basalt terrace. At a little way above this, the basalt has been wholly eroded from both sides of the cañon, excepting only an insignificant and badly broken patch on the south side; but immediately above this, the gorge becomes close, and the basalt is shown on both sides.

It is evident, then, that the cañons have been re-eroded partly along the original line or through the basalt, and partly alongside of the ancient

chasms, the basalt appearing sometimes on one side, sometimes on the other, and occasionally on both sides. One may easily determine whether or not the cañon is wholly beyond the limits of the ancient gorge, since if it be, the wall is sheer to the top; whereas, if the course be along the old channel-way, and the absence of the basalt be due to erosion, the bench previously covered by the lava is still distinct. The cross sections exhibit the features very satisfactorily; thus in passing from one cañon to the other at a little way above the junction, one would find the condition shown in Fig. 2.

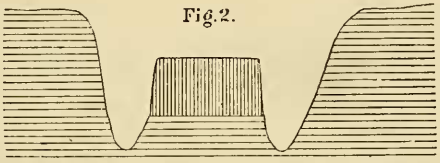

FIG. 2.—Section across cañons of Canadian and Mora rivers near their junction.

The basalt covers the level bench between the two cañons, while the higher wall of each is composed from top to bottom of the Dakota rocks. But at a mile and a half further up the streams the structure is as shown in Fig. 3 where the basalt appears on both sides of each cañon. Here both

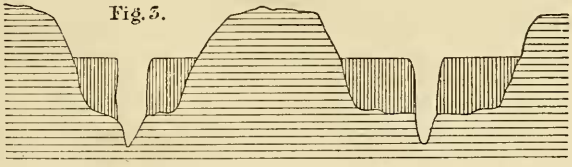

FIG. 3.—Section across cañons of Canadian and Mora rivers, two miles above their junction.

streams have cut their way through the basalt, whereas in the other, both cañons are outside of the sheet.

This new channel-way has been digged out of rocks of unequal hardness, and the corrasion seems to have gone on with equal rapidity everywhere. The gorge is as deep where the basalt plate appears in both walls as it is where the basalt is on one side or wholly away from the cañon. The only observable difference is that, where cut through the basalt, the cañon is very narrow, and the cutting has been confined to the immediate channel-way: whereas, the gorge is wide and shows a "bottom" where it has been worn in the sedimentary rocks only. The Canadian and the Mora are exceedingly rapid and very imperfectly loaded. Their corrasive power is far greater, therefore, than might be supposed, if their volume alone were considered.